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CORRELATIONS AMONG TERM STRUCTURE SLOPES IN EUROCURRENCY MARKETS

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ABSTRACT

Using data on Euro-rates for 1978-1996, we have examined the extent to which cross-country information on term structure slopes can be used to improve upon univariate slope forecasts. This is interesting from the point of view of forecasting economic activity, since term structure slopes have been shown in recent empirical work to anticipate fluctuations in the real economy. On the other hand, the Expectations Hypothesis states that the term structure slope summarizes the available information which is relevant for forecast future interest rates. We have found ample evidence of significant explanatory power in term structure slopes across countries. This leads to improved forecasts of the term structure slope, in some countries, using a foreign slope as indicator. However, the reductions in forecast error measures are not very large.

Keywords: *Term structure slope, Eurocurrencies.*
JEL classification: *E37, E43.*

1. INTRODUCTION

Recent empirical work by Estrella and Hardouvelis (1991), Stock and Watson (1988), Hardouvelis (1994) and Plosser and Rouwenhorst (1994), among others, has documented the existence of information in the term structure slope which is relevant to forecast future changes in economic activity. This is a notorious result, since it is the spread in nominal returns which turns out to be useful to forecast future changes in the real economy. Besides, the informational content in the term structure slope is additional to that in past economic activity, inflation, or even the leading indicators index, in the case of the *US*.

If changes in yield curve slopes in different countries were dynamically related, some of them could be used to predict changes in other countries' slopes better than forecasted from their own past alone and, as a consequence, potentially improve predictions of changes in economic activity. To explore this possibility in Euro-currency markets is the focus of this paper. An additional application of this study emerges from the *Expectations Hypothesis* of the term structure of interest rates, according to which, the slope summarizes all the relevant available information on future short-term rates. Again, if there is information in term structure slopes across countries, it might help to improve predictions of future interest rates, relative to using domestic data alone.

In the London eurocurrency market interest rates are quoted for deposits denominated in a variety of currencies and maturities. Being off-shore, deposits in the eurocurrency market share some important characteristics, like the fiscal treatment of returns or the timing of return payments, and they are not subject to possible government interventions like capital controls, which makes their observed returns more comparable than interest rates from domestic markets. We use monthly data on Euro-rates for the *US* dollar, Japanese yen, German mark, British pound, French franc, Italian lira, Swiss franc and Spanish peseta for 1978-1996 to compute their longer spread, that between returns on 12- and 1-month deposits, and examine their dynamic correlations across currencies.

After describing some specific details of Eurocurrency markets in Section 2, we specify and estimate regression models in Section 3 to capture the dynamics of the relationships between term structure slopes in different currencies, and measure the extent to which there is explanatory power

in slope fluctuations across currencies. In Section 4 we analyze whether the detected explanatory power across countries can be translated into improved slope forecasts. The paper closes with some conclusions.

2. THE DATA

Euro-currency markets originated in the 50's to take advantage of the fact that the *US* legislation allowed deposits in a currency other than the *US* dollar, kept abroad, not to be subject to reserve requirements. This mechanism generated a process which developed markets in a number of eurocurrencies, with basis in London. The development of Euro-currency markets was stimulated by the successive crisis in oil prices during the 70's, when oil producing countries invested their resulting current account surplus in them, and negotiated volumes have continuously increased since.

We transformed market rates into their annualized equivalent continuous form, and then compute the 12- versus 1-month spreads, to be used as term structure slopes in our analysis. Yields were very high at the beginning of the 80's specially in deposits in Spanish pesetas, French francs and Italian liras, as a consequence of the second oil crisis from 1979 and also because of expectations of impending devaluations, which would make the returns on these currencies to increase by the expected percent devaluation. In addition, higher volatility at the beginning of the sample is obvious in all series, again as a consequence of the oil shocks, which finally brought about a number of realignments in the *European Monetary System* (*EMS*), specially in the mentioned currencies. The final months of 1987 brought again instability in markets for exchange rates, as a consequence of the negative result of the Maastricht referendum in Denmark. To fight speculative attacks and introduce a more cooperative attitude among central banks, the *EMS* was reformed in the Nyborg-Basle accords in September of that year. All these events make advisable to use a shorter sample, starting in 1987 to leave the *old EMS* system out. In particular, Figure 1 shows the slopes from 1987 to 1996. Their graphs over the whole 1978-1996 period would be dominated by extreme values in the first years of the sample. There is widespread evidence of a decreasing trend in most cases, specially in the last part of the sample.

3. RELATIONSHIPS AMONG YIELD CURVE SLOPES ACROSS EUROCURRENCIES

A number of papers have provided evidence that Euro-returns on deposits in different maturities and currencies are related, although the appropriate interpretation of these relationships is still open to discussion. With data for 1979-1988, Karfakis and Moschos (1990) found that Euro-rates on 3-month deposits in German marks were Granger causal prior to those offered on deposits in a number of european currencies, in consistency with the existence of a *German mark-zone*. However, deGrauwe (1989), vonHagen and Fratiani (1990) and Katsimbris and Miller (1993) have argued against that result as an artifact of not taking properly into account the common effect of a third factor, *US* interest rates. In fact, in three-variate systems including returns on deposits on German marks, *US* dollars and one other *EMS* currency, these authors have found that rates offered on *US* dollar deposits tend to exhibit two-way Granger causality with those on deposits in european currencies, arguing for: a) a quite more complex set of interactions among interest rates across countries, and b) an almost equally important role for German and *US* interest rates in determining interest rates in *EMS* countries. With an enlarged sample for 1978-1996, Domínguez and Novales (1997) have found Euro-returns on different currencies at a given maturity to be cointegrated, as well as clear evidence that German rates are causal prior to those in other *EMS* countries, in line with the results of Karfakis and Moschos (1990). An increased leading role of German rates in recent years might explain the appearance of a clear causality ordering between interest rates in their more recent sample. These authors have also found two-way causality between interest rates in *US* and Germany, *US* and Japan, and Germany and Japan.

However, the positive results relating interest rates of a same maturity across currencies do not guarantee by themselves that an improvement in forecasting slopes will follow. First, the evidence in favor of cointegration among returns means that their long-run behavior is very similar, although leaving scope for them to experience possibly unrelated short-term fluctuations. Secondly, Domínguez and Novales (1997) have shown that the causality orderings between interest rates in different currencies implies explanatory power for short-run fluctuations which can actually be translated into some forecasting gain for future interest rates. But even that does not necessarily imply that their term structure slopes will fluctuate together, so that there may not be noticeable explanatory power between

slopes in different countries, and improving slope forecasts may not be simple.

In this Section we analyze the possible connections between term structure slopes across different Eurocurrencies, defined as the spread between returns on 12- and 1-month deposits, r_t^{12}-r_t^1. Given the relevance of the term structure slope to anticipate fluctuations in economic activity, such relationships might help predict the business cycle in a given country. Besides, the connection between slopes might also be useful for forecasting interest rates using information not only on the domestic term structure slope, but also on the slope from an influential country. Since we are interested on forecasting, we will search for dynamic correlations, measuring the extent to which a foreign slope, used as indicator, adds predictive power to a univariate dynamic model for a given slope.

Using Augmented Dickey-Fuller (*ADF*) tests at the 5% significance level in the more stable 1987-1996 subsample we reject the hypothesis that the term structure slopes contain a unit root except, marginally, for the Swiss franc, in spite of the fact that their graphs could throw some doubt about their stationarity, which might be reflected on the fact that the *ADF* statistics are not far from the critical values in any country [see Table 1 and Figure 2]. We stick to the results of the unit root tests and consider all slopes to be stationary, which allows us to use standard regression analysis as a valid way to summarize their dynamic interrelations.

The common membership to the *EMS* produced a close link between returns across countries, but also between term structure slopes, as shown by the contemporaneous correlation coefficients in Table 2. The only possible exception is the British pound, which has been in and out of the exchange system during our sample period, and seems to move closer to the *US* dollar, maybe because of the recent chronological syncronicity in their business cycles. Slopes for *US* dollar, yen and German mark term structures seem not to be contemporaneously very related. The *US* dollar slope does not show high contemporaneous correlation with those in european currencies other than the British pound. Most correlation coefficients get higher in the 1987-1996 subsample, shown in the upper submatrix in Table 2.

As it is the case with returns themselves, we would expect the slopes for interest rates on German mark and *US* dollar Eurodeposits to influence the slopes of the other european currencies, while the slopes of the *US* dollar, German mark and Japanese yen yield curves might show complex interactions. These relationships, which do not show up in Table 2, might reveal only with some dynamics. To test this set of hypotheses, we estimated an autoregressive model for each slope,

$$r_{1t}^{12} - r_{1t}^{1} = \alpha + \sum_{i=1}^{k} \beta_i (r_{1t-i}^{12} - r_{1t-i}^{1}) + \varepsilon_t$$

then adding to that model the term structure slope from the currency which is supposed to be influential,

$$r_{1t}^{12} - r_{1t}^{1} = \alpha + \sum_{i=1}^{k} \beta_i (r_{1t-i}^{12} - r_{1t-i}^{1}) + \sum_{j=0}^{s} \gamma_j (r_{2t-j}^{12} - r_{2t-j}^{1}) + u_t$$

where r_{1t}^{j}, $j = 1,12$ denotes the one and twelve month interest rates in the affected currency, while r_{2t}^{j}, $j = 1,12$ denotes the returns on the influential currency. If the slope for country 2 is, in fact, influential, we would expect to obtain a substantially higher R-squared (R^2) and a lower standard error of estimate (*SEE*) in the augmented regression model.

We use the German mark and *US* dollar slopes as indicators for the slopes of european currencies, and the term structure slopes of the *US* dollar, German mark and Japanese yens as indicators for each other. We just report estimates for the 1987-1996 subsample, since the higher interest rate volatility at the beginning of the sample produces an efficiency loss in estimation and a deterioration in forecasting performance. We started from a univariate $AR(3)$ model for the slope being predicted. Even though we did not perform a systematic search for a *best* model, the $AR(3)$ is flexible enough to accommodate a cyclical behavior, as well as a quite permanent component, if it existed. Estimated models are presented in the left column of each panel in Table 3, while the right column shows the models estimated after introducing another country's slope as an indicator, contemporaneously and with some lags. The sum of the estimated coefficients in the univariate $AR(3)$ model is high in all cases but it remains below one, except for the Spanish peseta, in consistency with stationarity of the slopes.

Our estimates show that there is widespread evidence that term structure slopes for different currencies contain relevant information on each other, even after the own past of the slope being explained has been taken into account. The German mark slope is dynamically correlated with the rest of european slopes, specially those of the Swiss franc, British pound and Italian lira. Its contemporaneous values, as well as its first lag, are always very significant in these regressions, except for the Spanish peseta. The *US* dollar slope shows some dynamics with respect to the Italian lira and Swiss franc. Except in the case of the peseta, the contemporaneous *US* slope is quite significant. In addition, the *US* dollar, German mark and Japanese slopes have significant explanatory power for each other, not only contemporaneously, but also with a one month delay. Although not

very precisely estimated, most long-run gains in these dynamic specifications are around one.

In our monthly frequencies the information content extends beyond the pure contemporaneous correlation, with some lags of the indicator being significant in each regression. This provides hope for extracting some forecasting gain from the use of indicator models, relative to univariate autoregressions. However, an improved fit does not necessarily come together with an improvement in forecasting ability, and we devote next Section to analyze the extent to which a given country's term structure slope can be used to improve forecasts on another country's slope, relative to those based on its own past alone.

4. PREDICTING TERM STRUCTURE SLOPES WITH CROSS COUNTRY DATA.

We discuss in this section the extent to which the in-sample explanatory power in term structure slopes across countries can actually be used to improve upon univariate forecasts. To that end, we report forecasts for the term structure slope in each currency, with and without one other country's slope as a possible indicator, using the models estimated in the previous Section. This is quite a strict request, since we are not just testing whether the slope in an influential country produces, by itself, good forecasts of the slope in another country. We rather test whether the influential slope adds any predictive power to the own past of the slope being forecasted.

We computed forecasts using the univariate $AR(3)$ model for each slope, as well as the model that includes another country's slope as indicator [Table 3]. The forecasting exercise consisted on estimating each model with data up to December 1995 and obtaining forecasts over 1996. We obtained *static* and *dynamic* forecasts. Static forecasts are one-step-ahead predictions, which use actual values for all explanatory variables, except the contemporaneous value of the indicator, which needs to be predicted. Dynamic forecasts are once-and-for-all predictions for the twelve months of 1996, calculated with models estimated using data up to December 1995. As we ran out of actual data in dynamic forecasting, we used previously obtained forecasts for the lagged slope being predicted, as well as for the contemporaneous and lagged indicator. To obtain forecasts for the indicator, an $AR(3)$ model was used again in both forecasting exercises, for the same reasons mentioned in the previous Section. The need to predict in advance the contemporaneous value of the indicator in static as well as in dynamic forecasting, occasionally led to notorious forecast deterioration. In those cases, we opted for using an estimated model with the same lag specification for the indicator as in Table 3, but without its contemporaneous value.

The period chosen for our forecasting test was not particularly easy. Slopes had been decreasing in all countries except Japan during 1995, reaching negative values, i.e., inverted term structure curves, in all countries by the end of that year [Figure 2]. The minimum slope was reached in November 1995 for the *US* dollar, German mark, British pound and Swiss franc, and the implied change in trend will make dynamic forecasts particularly hard in these countries. Slopes for the Italian lira and the peseta did not become positive during 1996, remaining quite stable at their low levels of the closing months of 1995, difficulting again their forecasts over a long period of time. Incorporating information from one period at a time, static forecasts might gradually account for these changes in behavior over 1996, relative to the previous year, and will obviously produce more accurate forecasts.

Percent Root Mean Square Errors or Mean Absolute Errors are not advisable, since the slope often becomes small in absolute value, to the point that even acceptable forecast errors might produce huge percent errors for a single period, dominating the value of any time aggregate forecasting performance indicator. Hence, we will use their versions in absolute terms. In addition, a rather large error in a particular month will also tend to produce a high average measure, so that the Median should be preferred to the Mean Absolute Error. Hence, we provide in Table 4 the Root Mean Square Error (*RMSE*), Median Absolute Error (*MAE*) and Theil's *U*-statistic as forecasting performance measures for univariate models as well as for models with indicators. The left column in each panel contains the error measures for univariate forecasts, while the remaining columns show error measures when an indicator is added to the forecasting model. The indicator name and lags used are shown on top of each column. Table 4 shows first the sample average absolute values of the slope being predicted, over the forecasting horizon, 1996:1-1996:12. This is the reference with which the Median absolute forecast error and the *RMSE* should be compared to evaluate forecast quality. Under the *RMSE* and *Median* absolute errors, Theil's *U*-statistic is presented.

Univariate models produced small average one-step-ahead forecast errors relative to the sample mean absolute slope for the British pound, Italian lira, Spanish peseta, *US* dollar and Japanese yen. For the French franc, Swiss franc and German mark, the median absolute forecast errors were above 50% of the average absolute slope. Once and for all, dynamic forecast errors were substantially higher in most countries, essentially because being obtained with information up to December 1995, they did not capture appropriately the trend change that took place in slopes during 1996. For the Spanish peseta, dynamic forecast errors were not as large, relative to static forecast errors, as it

should be expected.

Considering static, one-step-ahead slope forecasts for european currencies, the German mark only helps improve forecasts of the Spanish peseta slope. The *US* slope helps improve forecasts of term structure slopes for the Italian lira, Swiss franc and Spanish peseta. We have not found evidence that using either the German mark or *US* slopes improves forecast of slopes for the British pound or French franc. On the other hand, the yen slope helps improve forecasts of the German mark and *US* dollar slopes, while the *US* dollar slope improves forecasts of the German mark and Japanese yen slopes. Reductions in forecasting performance measures are not very large.

That the augmented model does not produce improved forecasts in some cases and may even deteriorate them, is due to the need to forecast the contemporaneous value of the indicator in static forecasting, and the contemporaneous and lagged values in dynamic forecasting. When actual values are used, forecasts [not shown here] significantly improved in most cases. On the other hand, omitting the contemporaneous indicator, as we have done in some cases, implies losing substantial information and, again, a decline in forecasting performance.

Cross-country information on term structure slopes can also be used to improve dynamic slope forecasts, and the percent reductions in error measures are bigger than in static forecasts. The *US* dollar slope improves univariate forecasts of French franc and Italian lira slopes, while the German mark slope improves univariate forecasts of the British pound and Italian lira slopes. The *US* dollar and yen slopes help improve forecasts of the German mark slope and the German mark slope can be used to improve forecasts of both the *US* dollar and Japanese slopes. These improvements in dynamic forecasting arise because the indicator helps to track somewhat the changed behavior of the slopes during 1996. Results for static and dynamic forecasting over each of the two semesters of 1996 show similar qualitative results.

In summary, we have found some indication that the German mark and *US* slopes help predict the slopes of some other european currencies. However, the evidence is not consistent across countries, and it is not clear that it is static, dynamic forecasts, or both, that are improved. We have also found evidence that German mark, *US* dollar and Japanese yen slopes predict each other. Nevertheless, these results should be taken as a lower bound on the forecasting power of cross-country term structure slope data, since we have used a standard *AR*(3) model to produce forecasts of the slope indicator in all cases. With that in mind these results look promising. Carefully searching for a good forecasting model, specific of each slope, might produce better forecasting results, and further clarify this issue.

The reduction in forecast error measures is not very large. That suggests that slope information across countries might be useful when using the term structure slope to predict future interest rates, but it will possibly not be a relevant contribution when using the term structure slope to forecast real economic activity. Besides, our results may be specific of the sample period and the forecasting models used. Both remain as interesting issues for further research.

5. CONCLUSIONS

We have examined the extent to which cross-country information on term structure slopes can be used to improve upon univariate slope forecasts. Obtaining good term structure slope forecasts is an important exercise, since term structure slopes have been shown in recent empirical work to anticipate fluctuations in the real economy. Hence, improved slope forecasts could hopefully be translated into better forecasts of real economic activity. In addition, the Expectations Hypothesis of the term structure of interest rates states that the slope contains all available information which is relevant to forecast future short-term rates. Hence, having good slope forecasts available might also be helpful to improve interest rate forecasts.

Using Euro-rates monthly data on the German mark, *US* dollar, Japanese yen, British pound, French franc, Italian lira, Swiss franc and Spanish peseta over 1978-1996, we have documented ample evidence of explanatory power in German mark and *US* dollar slopes relative to those of european countries. The Japanese yen, German mark and *US* dollar slope have explanatory power for each other. This is in all cases information additional to that contained in the own past of the slope being predicted. Our estimated models suggest important contemporaneous correlation between slopes, but also some significant lagged correlations, which could lead to improved forecasts.

Unfortunately, standard dynamic regression analysis does not necessarily produce better forecasts of a given country's term structure slope when one other influential slope is added to a univariate model, partly because the contemporaneous effect of the relationship between slopes needs to be predicted in advance. In spite of that, we have found that *US* dollar and German mark slopes can be used to improve upon univariate static and dynamic forecasts of european currency slopes in some cases. Static and dynamic forecasts of the German mark, *US* dollar and Japanese slopes can

sometimes be improved using each other as an indicator. It should be borne in mind, however, that we are not just testing whether an influential slope can produce good forecasts, but rather, whether adding the influential slope to a univariate model of the slope being predicted, improves forecasts.

When achieved, the reduction in forecast error measures is not very large, which suggests that it might be useful when using the term structure slope to predict future interest rates, but does not seem to be able to contribute significantly when using the term structure slope to forecast real economic activity. However, we have not performed an extensive search for the best forecast models for each slope but rather, we have used a common model in all cases. As a consequence, our results should be viewed as a lower bound on the ability of using slope correlations across countries to improve forecasts. Finding a better methodology to explore this question and characterizing a reasonable framework for transforming correlations between slopes across countries into improved forecasting performance remain as interesting issues for further research.

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Table 1

Augmented Dickey Fuller statistics for a unit root in eurocurrency term structure slopes.

Currency	*I*(0) *vs.* *I*(1)	*Model*	*Critical values* 1%	5%
US dollar	-4.31^{**}	4, c, t	-4.00	-3.43
Japanese yen	-4.52^{**}	4, c, t	-4.00	-3.43
German mark	-2.16^{*}	0	-2.58	-1.94
British pound	-3.46^{*}	4, c, t	-4.00	-3.43
French franc	-2.32^{*}	2	-2.58	-1.94
Italian lira	-3.02^{**}	1	-2.58	-1.94
Swiss franc	-1.90	4	-2.58	-1.94
Spanish peseta	-4.32^{**}	2, c	-3.47	-2.88

Note: The column labelled *Model* shows the number of lags used in the model for the differenced variable in testing for one unit root, as well as whether or not a constant, *c*, and a trend term, *t*, were included. An (two) asterisk denotes rejection of the null hypothesis at the 5% (1%) significance level.

Table 2

Contemporaneous correlation coefficients between slopes

	US dollar	*Japanese yen*	*German mark*	*British pound*	*French franc*	*Italian Lira*	*Swiss franc*	*Spanish Peseta*
US dollar	1	0.23	-0.05	0.58	0.08	0.21	0.31	0.09
Japanese yen	0.31	1	0.41	0.52	0.40	0.32	0.58	0.39
German mark	-0.02	0.37	1	0.20	0.84	0.57	0.65	0.70
British pound	0.53	0.50	0.16	1	0.25	0.33	0.63	0.43
French franc	0.04	0.18	0.28	0.12	1	0.52	0.59	0.60
Italian lira	0.26	0.41	0.43	0.27	0.63	1	0.49	0.51
Swiss franc	0.30	0.50	0.64	0.55	0.19	0.36	1	0.54
Spanish peseta	0.11	0.30	0.56	0.31	0.40	0.41	0.40	1

Note: The lower triangular matrix shows contemporaneous correlations between slopes for the whole 1978-1996 sample. The upper triangular matrix shows correlations for the 1987-1996 subsample.

Table 3.a

Regression models for term structure slopes

	British pound			*French franc*			*Italian lira*			*Swiss franc*			*Spanish peseta*		
Constant	-0.014	-0.027	-0.128	-0.032	-0.078	-0.031	-0.036	-0.036	-0.092	-0.020	-0.015	-0.052	-0.047	-0.054	-0.109
	(0.029)	(0.027)	(0.034)	(0.042)	(0.040)	(0.047)	(0.061)	(0.059)	(0.066)	(0.028)	(0.023)	(0.028)	(0.057)	(0.047)	(0.066)
		Own lags			*Own lags*			*Own lags*			*Own lags*			*Own lags*	
$i=1$	1.127	1.103	0.957	1.083	0.797	1.018	0.489	0.390	0.442	0.665	0.679	0.696	0.594	0.387	0.507
	(0.098)	(0.101)	(0.096)	(0.097)	(0.103)	(0.094)	(0.099)	(0.101)	(0.096)	(0.096)	(0.083)	(0.086)	(0.160)	(0.174)	(0.099)
$i=2$	-0.345	-0.368	-0.339	-0.406	-0.414	-0.399	0.224	0.208	0.307	-0.059	-0.072	-0.009	0.388	0.484	0.468
	(0.144)	(0.148)	(0.130)	(0.138)	(0.118)	(0.129)	(0.108)	(0.108)	(0.108)	(0.116)	(0.087)	(0.088)	(0.139)	(0.144)	(0.107)
$i=3$	0.159	0.207	0.241	0.211	0.144	0.281	0.068	0.010	0.065	0.273	0.228	0.227	-0.133	-0.050	-0.070
	(0.098)	(0.100)	(0.089)	(0.094)	(0.094)	(0.093)	(0.098)	(0.100)	(0.097)	(0.096)	(0.074)	(0.077)	(0.096)	(0.100)	(0.102)
		GM lags	*US lags*		*GM lags*	*US lags*		*GM lags*	*US lags*		*GM lags*	*US lags*		*GM lags*	*US lags*
$j=0$		0.379	0.287		0.824	0.305		0.808	0.748		0.702	0.557		1.113	0.352
		(0.119)	(0.090)		(0.182)	(0.152)		(0.281)	(0.226)		(0.106)	(0.090)		(0.325)	(0.205)
$j=1$		-0.447	0.027		-0.267	-0.049		-0.532	-0.505		-0.601	-0.408		-0.437	0.045
		(0.152)	(0.095)		(0.193)	(0.189)		(0.275)	(0.228)		(0.112)	(0.096)		(0.301)	(0.255)
$j=2$		0.178				-0.243								-0.239	0.018
		(0.159)				(0.148)								(0.289)	(0.242)
$j=3$		-0.171												-0.208	-0.133
		(0.125)												(0.233)	(0.193)
R^2	0.89	0.90	0.91	0.79	0.81	0.78	0.49	0.52	0.53	0.67	0.77	0.76	0.72	0.77	0.73
SEE	0.268	0.252	0.242	0.402	0.373	0.406	0.611	0.587	0.582	0.275	0.230	0.233	0.529	0.478	0.525

Note: The left column in each panel contains the univariate model estimates. The remaining columns present estimates of the model with indicator. R^2 and *SEE* denote the coefficient of determination and standard error of estimate of each regression, respectively.

Table 3.b

Regression models for term structure slopes

	German mark			US dollar			Japanese yen		
Constant	-0.011 (0.021)	0.011 (0.020)	-0.022 (0.019)	0.039 (0.031)	0.038 (0.023)	0.037 (0.024)	-0.012 (0.024)	-0.016 (0.021)	-0.032 (0.024)
	Own lags								
j=1	0.869 (0.099)	0.783 (0.099)	0.984 (0.100)	0.838 (0.100)	0.850 (0.075)	0.898 (0.098)	0.630 (0.096)	0.644 (0.087)	0.667 (0.090)
j=2	0.212 (0.130)	0.157 (0.123)	0.022 (0.139)	0.034 (0.130)	-0.087 (0.098)	-0.150 (0.132)	-0.041 (0.115)	-0.083 (0.103)	0.014 (0.101)
j=3	-0.150 (0.099)	-0.013 (0.098)	-0.019 (0.102)	-0.030 (0.100)	0.066 (0.076)	0.088 (0.092)	0.240 (0.096)	0.265 (0.088)	0.199 (0.087)
		Yen lags	US lags		GM lags	Yen lags		GM lags	US lags
j=0		0.402 (0.087)	0.492 (0.067)		0.711 (0.096)	0.706 (0.097)		0.432 (0.094)	0.379 (0.077)
j=1		-0.208 (0.105)	-0.461 (0.101)		-0.776 (0.096)	-0.854 (0.145)		-0.429 (0.094)	-0.292 (0.080)
j=2		0.100 (0.106)	0.140 (0.110)			0.125 (0.165)			
j=3		-0.128 (0.093)	-0.093 (0.077)			-0.037 (0.122)			
R^2	0.87	0.89	0.91	0.69	0.81	0.76	0.58	0.65	0.66
SEE	0.213	0.197	0.176	0.267	0.210	0.235	0.227	0.206	0.204

Table 4.a

Forecasting performance measures

	British pound			French franc			Italian lira			Swiss franc			Spanish peseta		
Indicator[a]		GM (1,2,3)	US (1)		GM (1)	US (1,2)		GM (0,1)	US (0,1)		GM (0,1)	US (0,1)		GM (0,1,2,3)	US (1,2,3)
Sample absolute mean values[b]: 1996:1-1996:12	0.310			0.198			0.845			0.196			0.481		
Static forecasts[c]															
RMSE	0.146	0.148	0.222	0.151	0.197	0.151	0.259	0.360	0.238	0.201	0.205	0.209	0.149	0.128	0.151
Median	0.062	0.058	0.142	0.096	0.130	0.107	0.231	0.357	0.190	0.131	0.124	0.114	0.125	0.108	0.105
U	0.264	0.269	0.372	0.356	0.479	0.345	0.172	0.261	0.155	0.515	0.520	0.505	0.155	0.136	0.150
Dynamic forecasts															
RMSE	0.534	0.467	0.928	0.527	0.698	0.419	0.583	0.537	0.439	0.405	0.440	0.500	0.154	0.179	0.321
Median	0.499	0.423	0.951	0.509	0.700	0.431	0.577	0.530	0.402	0.373	0.408	0.479	0.046	0.171	0.333
U	0.834	0.802	0.887	0.964	0.974	0.935	0.505	0.448	0.336	0.936	0.939	0.943	0.171	0.211	0.257

Table 4.b

Forecasting performance measures

	German mark			US dollar			Japanese yen		
Indicator[a]		Yen (0,1,2,3)	US (1,2,3)		GM (1)	Yen (0)		GM (0,1)	US (0,1)
Sample absolute mean values[b]: 1996:1-1996:12	0.112			0.310			0.321		
Static forecasts[c]									
RMSE	0.127	0.109	0.120	0.150	0.152	0.146	0.156	0.160	0.153
Median	0.084	0.064	0.080	0.132	0.128	0.127	0.122	0.113	0.121
U	0.404	0.350	0.386	0.217	0.228	0.205	0.248	0.258	0.235
Dynamic forecasts									
RMSE	0.397	0.279	0.348	0.312	0.221	0.242	0.364	0.356	0.385
Median	0.407	0.279	0.349	0.271	0.171	0.204	0.302	0.301	0.323
U	0.811	0.744	0.783	0.594	0.387	0.446	0.955	0.948	0.968

Notes:

a) The left column in each panel shows performance measures for univariate forecasts. The remaining columns contain performance measures for models with indicators. The indicator and lags used are shown on top of each column.

b) Mean absolute values of the slope over the forecasting horizon.

c) *Mean* and *Median* are the mean and median absolute values of the forecasting errors. *U* denotes Theil's statistic.

Figure 1

TERM STRUCTURE SLOPES: 1987-1996

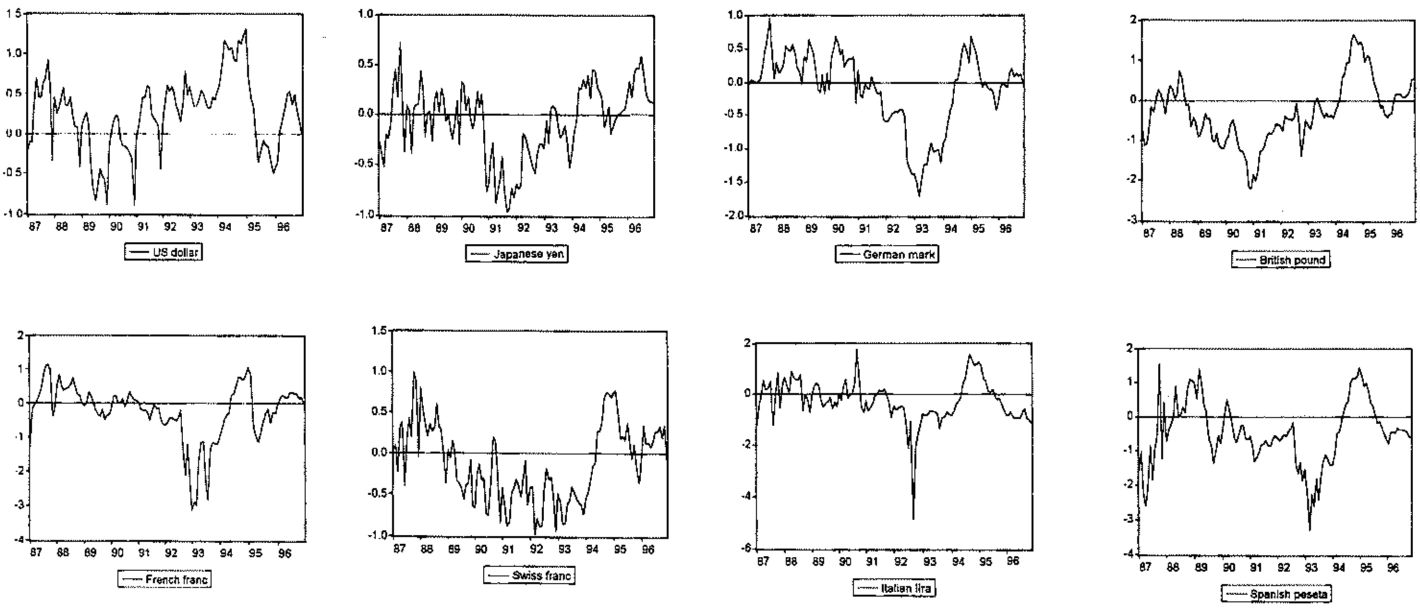

Figure 2

TERM STRUCTURE SLOPES:
1995:1 - 1996:12